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TACTICS IN THE DEVELOPMENT OF MINE DETECTOR DOGS

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Dogs have been known to find hidden explosive artifacts and to provide behavior indicators of the detections. (1)(2) The United States Army during World War II devised a method for training dogs to discover buried metallic and non-metallic mines, trip wires and booby traps. The dog indicated the object's position by sitting from one to four paces distant from it. The dog was worked on-leash in mine-fields and on reconnaissance patrols. The principle of avoidance was the basis for learning - the dog was taught to fear and avoid the artifacts. The method apparently produced some behavior problems, e.g., the indicator response was often made too distant from the object to be of much use in locating it, and the dogs occasionally refused to move forward in search.

This paper describes the development and characteristics of two other U.S. mine dog systems. The Mine Detection Dog was recently made operational and has undergone a 6 month evaluation in RVN. (3) The Specialized Mine Detection Dog is currently in development. The training procedures for both have been based on the reward or approach principle of learning.

THE MINE DETECTION DOG

The operational Mine Detection Dog works off-leash about 30 meters ahead of a patrol on trails and in open fields at a speed of about 3 km/hr. It locates explosive ordnance, surprise firing devices and trip wires by sitting within two feet of them. This system is essentially similar to the British Arms Recovery Dog concept, except that the latter uses the on-leash mode and lacks a trip wire finding capability. (2)

Exploratory Work in Stimulus Learning

The success of a dog's ability to make the conditional sit response correctly to some objects and reject others during military

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operations depends on what it learned in mine detection training. Experimental data show that the dog learns a good recognition to a single previously neutral odor in several hundred trials, and reliable perceptions at threshold levels of the same odor stimulus in a thousand or more trials. Clearly, no dog can be given discrimination training to each of the many kinds of available U. S. and foreign ordnance and to the vast set of home-made surprise firing devices, and later be expected to recognize all of them when encountered during operations. But, according to the generalization learning process, if an animal learns to respond to a particular stimulus, other previously neutral stimuli will also elicit the conditioned response if the stimuli are judged perceptually "similar." Early in the system development, the assumption was made that a dog could make a correct determination about many explosive artifacts never before experienced, on the basis that some similarity of components runs across these objects. A mine simulant was thought to be an appropriate object for obtaining stimulus generalization learning, and was used in the early exploratory work. It was comprised of broken pieces of a Claymore mine, a filter paper dusted with an explosive powder, metal pieces, field wire, and a dab of cosmoline, all enclosed in a piece of cloth and tied. Later, in production training, the first phases of learning were accomplished with mine simulants, which containing materials were now enclosed in a "cricket can," and the latter phases used 6 or more representative explosive ordnance pieces to supposedly complete the generalization process.

The early work investigated the conditions under which dogs can detect mines and the factors which affect their performance. The first experiment attempted to find out how well dogs could locate hidden mine simulants. Following stimulus learning, the mine simulant objects were tossed between one to three feet beyond the edge of a narrow dirt road into semi-dense brush. Eight mine simulants were positioned randomly along 150 yards of the road. Food was used to reward sit responses within 2 feet of the found object. A correction technique was used whenever a dog went past the planted mine: The dog was recalled and made to sit at the mine position for one minute. It was given a chance to approach again the missed mine position from a point about 10 yards back down the road. If the dog found the mine on the second try, it was praised and petted, but not food rewarded. Ultimately, all four dogs used showed performances which stabilized at 1 to 3 correct mine simulant finds out of 8, on the average, for any run. At that point, it was decided to give the dogs more trials per problem by having them run in the reverse direction over the same course. Based on learning principles relating to delayed response, memory was not expected to play much part in finding the mines, the location of which were experienced in the first leg of the run. All dogs made almost perfect runs on the second leg.

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The second experiment was designed to test the hypothesis that dog odor traces left by a sitting dog are a significant cue used by the dogs to find the mine simulants. All dogs were tested over the same programmed run. Every dog had an equal chance to be the first animal run on any day. The first dog continued to show no better performance than that made earlier on a newly encountered mine trail. However, dogs in the second, third and fourth positions made perfect or near perfect runs. The conclusion was clear that dogs can find mines by tracking the odors of other dogs which had also found them.

Another experiment tried to establish how well dogs could find mines which were more than two feet from positions sat at by other dogs. Only two dogs were run on any programmed trail. The first dog sat at every mine on the run for one minute, either as a correct response or by correction. At the end of the sitting time, the mine was picked up and tossed 3 to 8 feet from the original position. The second dog typically showed strong search behavior about the position where the first dog sat. There appeared little or no approach in the direction of the mine object until it came to within about two feet of the object.

Detection Strategy

Further observations made during the training of dogs for operational use showed that the animals made use of secondary cues, such as disturbed earth odors and human odor traces, in finding hidden mines.

A simple test was conducted with trained Mine Detection Dogs to determine if ordnance objects which lacked emplacement associated cues could readily be found. A minelayer dropped fragmentation grenades 2-3 feet to the side of a trail, while walking at a rapid pace. All objects could be seen by anyone passing by. Results showed that the dogs found and sat at 30 per cent of the grenades. It seems that, because of the apparent weakness of most mine odors, a mine dog must learn to recognize other stronger cues which are frequently associated with mine emplacement, if it is ever to become an effective mine finding instrument. The secondary cues and not the mines or any of their components appear to elicit the classic "alerting" response, followed by a search for the odor source. It is then that the dog can finally make a determination if a mine is present.

Another simple test was made to find out whether the dogs recognized mine odors as such. Two special problems were included in runs, for eight animals, which also had the usual number of mine artifact problems. For one new problem, holes were dug and conditionally neutral objects, such as empty milk cartons and empty soft drink bottles and cans, were buried and camouflaged. In the other problem, holes were dug, nothing put in them, and camouflaged. Three of eight dogs inspected the holes containing the neutral objects, but did not sit at them. Five dogs found the holes and sat at them. In this

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same group, all dogs discovered the holes which did not have anything in them. Four sat by them and four did not. This test showed that perhaps there is some recognition for the class of objects called explosive artifacts, but the notion that some dogs are finding mines without smelling mine odors or their components cannot be discounted. The strategy of some dogs may be merely to determine if there is some object present - any object - at a position which gives off reinforcing secondary cues. During these tests, it was also found that trained dogs rarely give false responses in the absence of secondary cues or conditional artifacts.

The detection of trip wires is probably made by sight, but before the sighting is made, in most cases, the dog stops abruptly on the track of the person which laid the trip wire across the line of movement.

Versatility

In a debriefing, two mine dog handlers reported that their dogs made clear readable reactions to Viet Cong waiting in ambush. The handlers were able to "read their animals" and correctly identify the odor stimulus which elicited the behavior. It is inherent in the dog to alert to humans naturally, but these reactions are not readily observable in some dogs, and the reaction can be extinguished through experience in others. However, procedures are simple for obtaining and maintaining this secondary detection capability without diminishing the dog's ability to find mines.

Several instances were related of mine dogs finding camouflaged ground cavities, i.e., punji pits, cache holes, etc. The phenomenon can be predicted from the procedures which bring about the mine finding behavior. During training, mines and holes in the ground frequently are closely associated. Ground cavity odors become discriminatory stimuli to a mine dog when they aid in getting the dog to a place where mines are likely to be found. The dog's behavior while checking out a ground cavity for the presence of mines is so strikingly characteristic that the handler will himself investigate the area of dog interest, even when the dog happened to move on without sitting.

The conditioned sit response is not appropriate when made to human and ground cavity stimuli. In one instance, an observable momentary distraction by the dog must be accepted as the indicator of stimulus presence. In the other, the stimulus is an integral part of the dog's mine finding strategy and the investigatory response should be the indicator.

The mine dog can be used to clear a path through a mine-field, if it had been recently laid, without any additional training. And such a field could be systematically cleared with an adjustment only in the dog's terrain-working behavior.

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The assignment of more than one handler to each dog is being tried. The handlers alternate in grooming the dog and providing it with exercise and maintenance training on an equal basis. The dog should work with any handler assigned to it, regardless of the kind of personal relationship established between them - the handler should otherwise serve as a vehicle for getting the hungry animal to a place where it can find food. To show also that most dogs will quickly adapt to a new handler, a test was arranged to have dogs run on a practice mine trail with a stranger handler. The handler was given one minute to become acquainted with each dog before a run. The criteria of good cross-handler working ability was moving out on command and purposefully going down the trail for a distance of 50 yards. Fourteen of seventeen dogs met these criteria.

Operational Evaluation

Fourteen Mine Detection Dogs were sent to the Republic of Vietnam for a 6-month evaluation and a partial summary of results follows: The mine dogs made 76 positive responses on ordnance and trip wires; 21 positive responses on tunnels, punji pits, caches and spider holes; 6 alerts on enemy personnel; and 14 alerts that were not checked by the supported unit. There were 12 confirmed cases where mine dogs missed an artifact. Several misses were on ordnance and explosives that had been emplaced for a long period. Two misses were 30-pound plastic mines of ammonia nitrate. Three misses were antitank mines. Two of these misses occurred after heavy rains. Both were also missed by mine sweep teams. Detecting ordnance that had been emplaced for a long period seemed to be a problem for the mine dogs. (3)

SPECIALIZED MINE DETECTION DOG

The Specialized Mine Detection Dog System is now in development. It was designed to locate plastic antipersonnel fragmentation mines which were buried for durations of several months or longer. The dogs shall be used off-leash between guide tapes in minefields and make their conditioned sit response within two feet of the buried mine.

The British Mine Dog is also a minefield dog⁽²⁾, but the system differs importantly from the current one in the way that the respective dogs locate mines. The assumption guiding our procedures is that there are no accessory cues other than mine odors in some minefields which can guide the animal to a mine's location. The British Mine Dog appears to be using mine-emplacement generated secondary cues in its strategy because the animal has difficulty locating mines as emplacement duration increases.

In training the dog, odors from earth disturbance made during daily mine laying must be reduced considerably. The procedure

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which is used to reduce these odors is one which does not require hole digging for mine burial. Several hundred upright ceramic sleeves shall be emplaced throughout the experimental minefield and shall remain in place for the duration of minefield use. Into them shall fit ceramic containers, some of which hold soil and a mine, and others which hold only soil. The containers can be removed and replaced with other containers for any test session. The entire field then shall be given a light raking to hide container positions from sight.

The presence of human odor traces during trial runs can be minimized if the person who lays out the minefield daily does not thereby make physical contact with the ground. A cart was designed for use in the training minefield. It permits the minelayer to lie prone about 14 inches above ground level while he does his work.

Feasibility of the Specialized Mine Dog System shall be tested in mid-1970 on a 9-month old minefield at the Aberdeen Proving Ground, Maryland.

FUTURE RESEARCH

An olfactometer was designed recently to study experimentally some of the factors which relate to mine detection by dogs. The instrument precisely regulates the quality and intensity of odor stimuli, uncontaminated by affecting impurities. Air flow, shown in the diagram of figure 1, begins at the motor compressor and passes through a vessel immersed in an isopropyl alcohol and dry ice bath - the air is purified by means of condensation at low temperature. At valve X, the flow is diverted into any of three odor producing branch lines. In our work, the liquid sparger was used specifically to obtain conditioning of animal behaviors which were required later for testing experimental odorants. Amyl acetate provided an easily discriminable odor for this pre-experimental purpose. The sample chamber in the second branch can contain solid substances such as explosives and ordnance items. The third branch leads to a series of simulated environmental fields, consisting principally of tubs containing soil and Bell jar housings. The saturated odorants and several dilution intensities are shown as lines A through J on both sides of the manifold. The system is in flow equilibrium - the lines are either opened to the manifold or to waste. Once the saturation levels have been determined for any odorant line, they should remain constant throughout a session.

The instrument is capable of delivering one or two qualitatively different odorants or clean air to the animal on any trial. For example, the air flow from the sample chamber containing a mine could mix with the air flow from one of the tubs containing only soil and be delivered to the animal on the same trial. In this manner, the odor intensities from the mine and soil can each be systematically varied during an experimental session, and the effects of one on

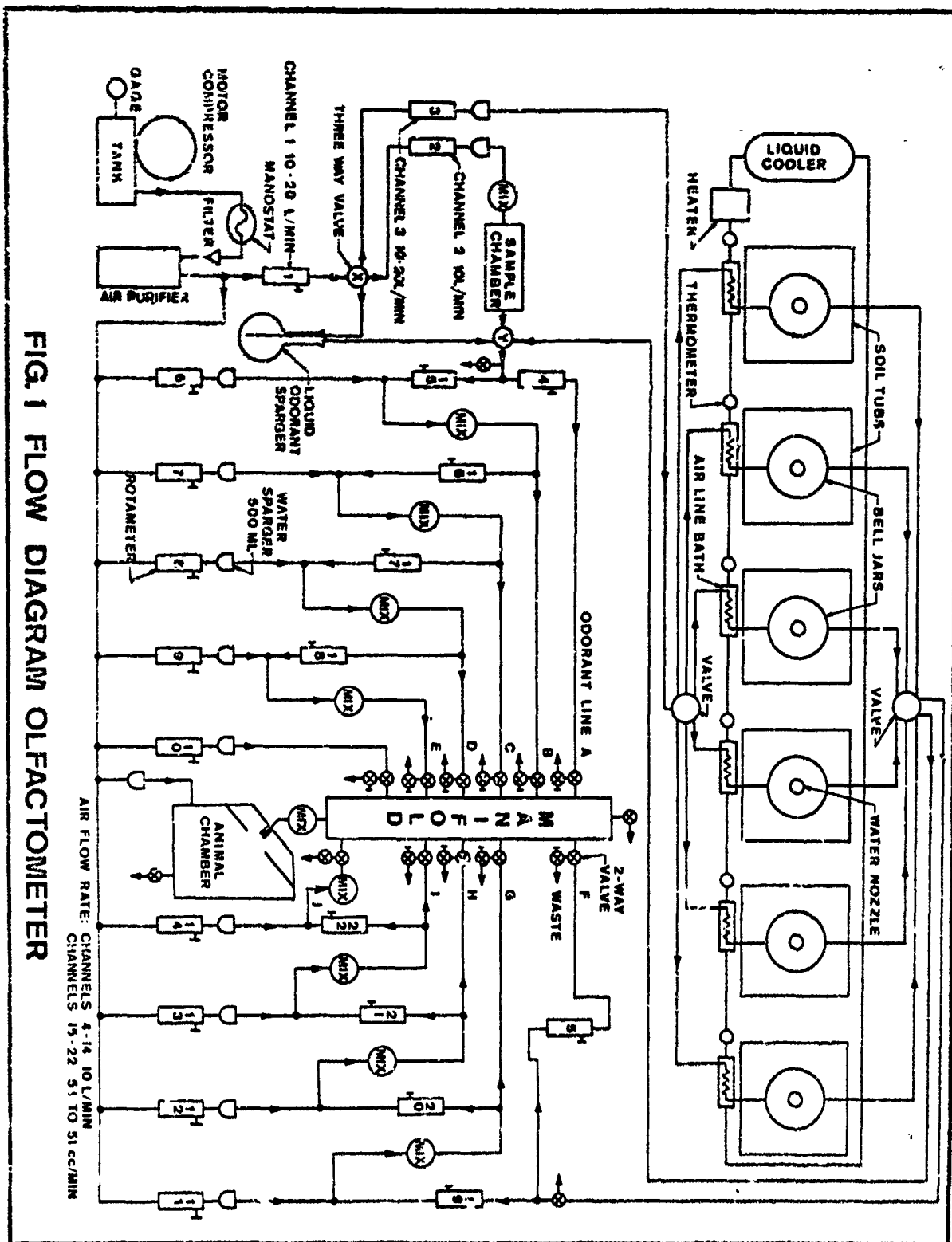


FIG. 1 FLOW DIAGRAM OLFACTOMETER

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the other can be established.

Matters of importance to developers of detector-dog systems are: The olfactory sensitivity of the dog to various substances of military significance. From the limited data available on the dog's olfaction capabilities, this animal shows remarkable odor detecting powers, although degree of sensitivity will be expected to vary considerably over the broad spectrum of discriminable odors - the dog's ability to smell some floral scents apparently is no better than what man can do. The masking effects of background mediums on the conditional odorant. Except as a laboratory phenomenon, the conditional odorant shall appear with other odors in air that the dog normally breathes and are expected to exert some masking. Individual animal differences in discriminability. The selection of dogs for any detector program on the basis of olfactory acuity should be made on how the dogs are distributed along the sensitivity continuum and how various sensitivity levels affect performance in applied situations. The effects of training conditions and procedures on the system performance. The selection of the correct training variables depends currently on the skills and experiences which the developer hopefully has had in related fields of animal learning. Procedures selected for the systems must at some time be experimentally evaluated for appropriateness and effectiveness.

The improvement of present detector-dog systems and the development of other systems will come about through continuing evaluation of fielded systems and through experimental work in both open-field trials and the laboratory, the latter conducted especially with olfactometry.

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